OA-21

Electron beam periodical poling in [001]c-poled PMN-39PT single crystal

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The $Pb(Mn_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMN-PT) ferroelectric single crystal is a very attractive material for nonlinear optical application due to the estimated nonlinear-optical coefficients. This requires methods of precise control of domain wall positions for the creation of precise periodical domain structures [1].

We have used charge injection by controlled e-beam irradiation [2] of the artificial surface dielectric layer covering PMN-PT single crystal to create the tailored domain structure. The domain formation has been studied experimentally. The results explained in terms of kinetic approach [3].

We revealed the switching of *c*-domains leading to formation of the tailored domain structures. We have measured the dose dependence of the shape and size of isolated domain as a result of dot irradiation. The switched domain area demonstrates the typical linear dose dependence up to 50 pC while at higher doses goes to saturation with a large dispersion (Fig. 1a). The linear dependence can be attributed to screening of depolarization field by injected charge. The obtained saturation is caused by electrostatic interaction of domain walls or influence of *a*-domains. The domain shape changes with dose increase from circular (Fig. 1b) to irregular.

We used the line and stripe irradiation mode for creating 1D periodical patterns (Fig. 1c). The increase of the width of stripe domains at the irradiated surface with dose has been revealed. The appearance of the fingers at domain walls oriented mainly at the angle close to 45º relative to [100] direction was revealed at the highest doses.

We have demonstrated the ability to create the stripe domains along arbitrary direction as well as ring-shaped domains (Fig. 1d). Since any area element consists of discrete points the circle domain shape upon dot irradiation at low doses is the key point which allows us to produce domain patterns with arbitrary geometry. The width of stripe domains was independent on direction. The confocal Raman microscopy modified for PMN-PT was used for domain imaging in the crystal bulk [4]. We have shown that domain grew down to 200 μm while periodical pattern conserved down to 30 μm. The obtained knowledge can be used for creating elements with periodical domain structures for light frequency conversion.

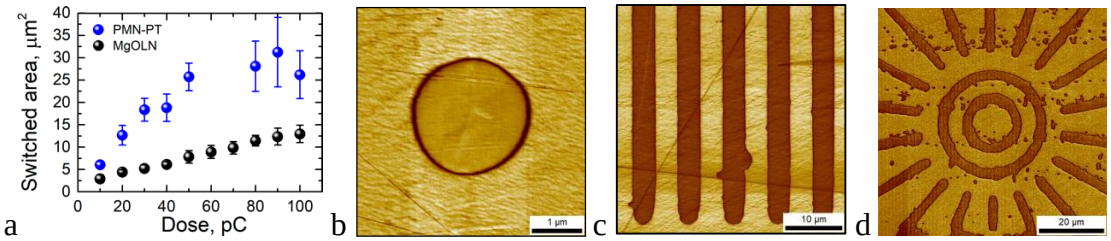

Figure 1. (a) The dose dependence of switched domain area for MgOLN and PMN-PT crystals, PFM images of c-domain structure created by: (b) dot irradiation, (c) stripe irradiation along [100] direction with period of 8 μm, (d) irradiation along arbitrary directions.

The equipment of the Ural Center for Shared Use "Modern Nanotechnology" UrFU has been used. The research was made possible in part by RFBR (grant 17-52-80116-BRICS_a).

1. V.Ya. Shur, A.R. Akhmatkhanov, and I.S. Baturin, *Appl. Phys. Rev.* **2**, 040604 (2015).
2. V.Ya. Shur, D.S. Chezganov, et al., *Appl. Phys. Lett.* **106**, 232902 (2015).
3. V.Ya. Shur, *J. Mater. Sci.* **41**, 199 (2006).
4. P. Zelenovskiy, E. Greshnyakov, D. Chezganov, et al., *Crystals* **9**, 65 (2019).